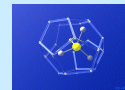


## Hydrate Production And Safety

### Commercialization of Natural Gas Hydrates

GOM Hydrates R&D Planning Workshop  
August 9-10, 2000

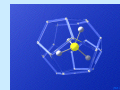
by Emrys H Jones  
Chevron Petroleum Technology Co.



## Hydrate Production And Safety

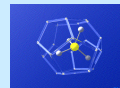
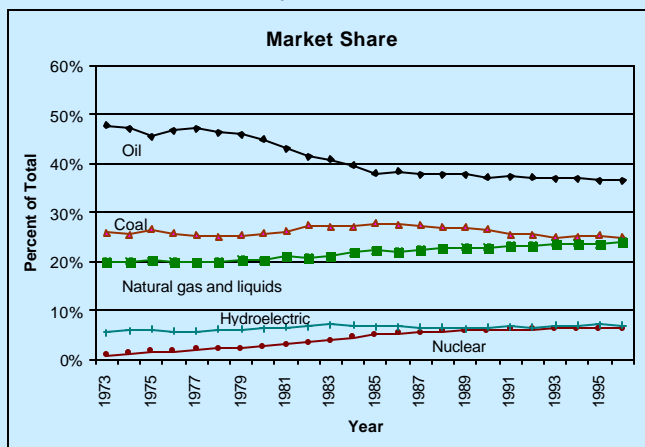
### Natural Gas Supply and Demand

- Long term trends that could affect the supply/ demand balance.
- Step changes that may affect the supply/ demand balance.



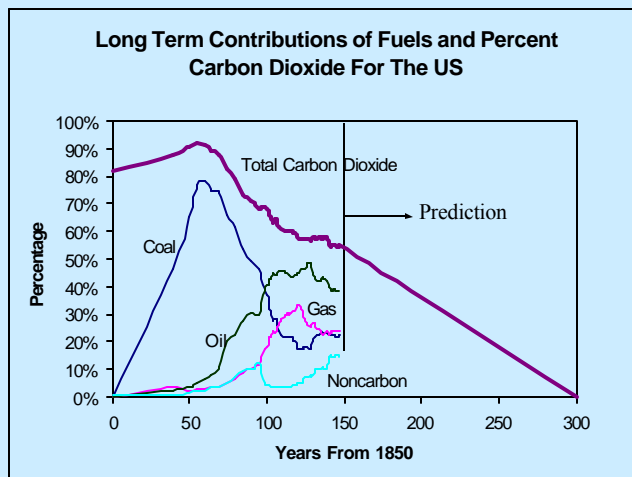
## Hydrate Production And Safety

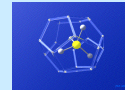
World wide gas has been increasing its market share for at least the last 25 years.



## Hydrate Production And Safety

From the beginning of this century the U.S. has been reducing the percent carbon it burns for fuel.

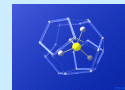
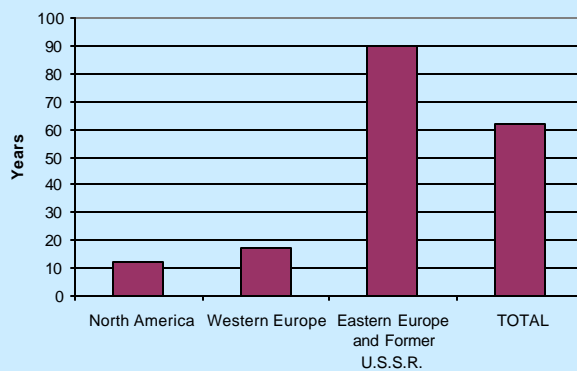




## Hydrate Production And Safety

The united states will have to import a large part of its natural gas early in the 21st century. (USGS estimates of hydrate gas off the southeast U. S. coast are about 1,000 years at current demand levels)

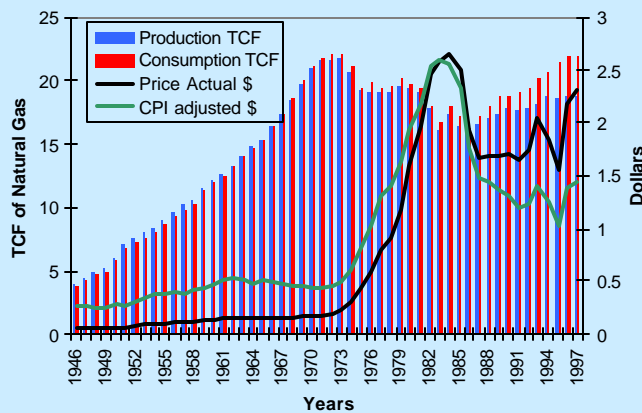
Years of Supply at 1996 Consumption levels

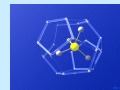


## Hydrate Production And Safety

US natural gas price and consumption have varied greatly in the past.

US Natural Gas Last 50 Years





## Hydrate Production And Safety

Could anything alter the supply demand picture?

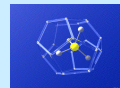
Yes

People have historically changed fuels for the following reasons:

If consumers view it as cleaner and easier to use.

Or

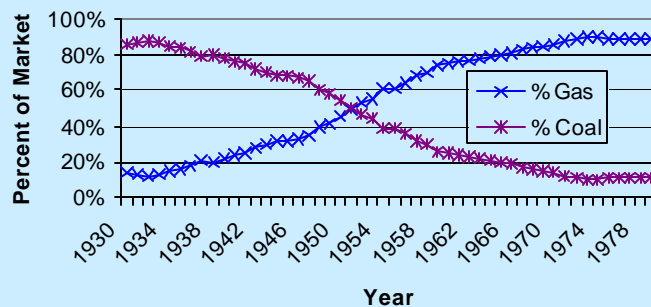
If a new technology is commercialized that provides more economic industrial application

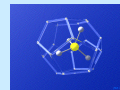


## Hydrate Production And Safety

It took 40 years for natural gas to displace coal in the residential, commercial and industrial markets.

### Natural Gas Replaces Coal For RCI

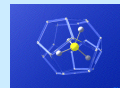
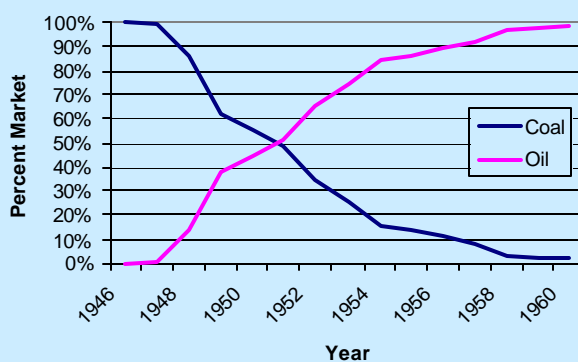




### Hydrate Production And Safety

But only 15 years for oil to replace coal as the prime railroad transportation fuel.

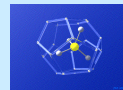
Oil Replaces Coal In Railroad Use



### Hydrate Production And Safety

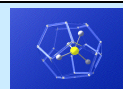
#### Summary of Economic Conditions Necessary for Hydrate Gas Production

- In the short term (5 to 10 years) hydrate gas will have to compete with conventional supplies at an inflation adjusted price of around \$1.50/MCF.
- Mid term (10- 20 years) hydrate gas will have to compete with liquefied natural gas (LNG) at a current cost of \$3 to \$4 /MCF.
- Green fuel concerns will increased demand for natural gas world wide.
- Methane hydrates are an excellent feed stock for modern fuel cells, being developed for transportation, and also for nearly every petroleum product.
- Hydrates offer the potential massive reserve base necessary for business and consumers to change from coal and oil to a stable and some what cleaner methane fuel (some hydrates contain other hydrocarbons).



## Hydrate Production And Safety

What technology needs to be developed to economically produce hydrates?

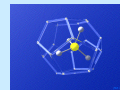


## Hydrate Production And Safety

Presenting The Case To Management For Funding



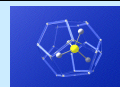
So you only need a billion dollars to develop this hydrate play. But before we put our money on the table we need a few questions answered.



### Hydrate Production And Safety

Petroleum companies invest on an expected value basis which is a risk weighted net present value.

- Expected Value = Revenue - Cost
- Revenue
  - How much is there
  - How fast can it be produced
  - What is the market price
- Cost
  - Exploration
  - Drilling and completion
  - Facilities and transportation
  - Operating



### Hydrate Production And Safety

The current bottom line is:

State-of-the-art infrastructure and drilling technology with known flow rates from hydrate wells implies that a stand alone hydrate development is uneconomical at current US natural gas prices.

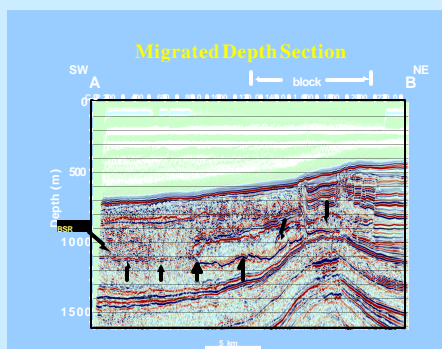
## Hydrate Production And Safety

### Technologies that need improvement

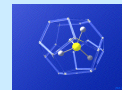
- Improved geophysical tools that increase confidence in the presence and quantity of hydrates and also help determine the mechanical properties of the sediment for safety and facility design.
- Improved reservoir modeling to determine the flow rate for different production systems.
- Low cost and safe drilling and completion systems for hydrate reserves.
- Low cost production systems.
- Co-production of conventional gas could speed utilization by helping with economics.

## Hydrate Production And Safety

Seismic data (return times and amplitudes of acoustic waves) are currently not sufficiently accurate to determine the amount, location, or presence of hydrates.



- Hydrates have been found with no BSR present.
- BSR's have been present with no hydrates present.
- Advancements in seismic attribute analysis could improve the ability to determine the presence of hydrates and concentration estimations.

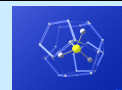


## Hydrate Production And Safety

The mechanical properties of hydrates need to be determined for facility design, well bore integrity, and reservoir flow analysis.

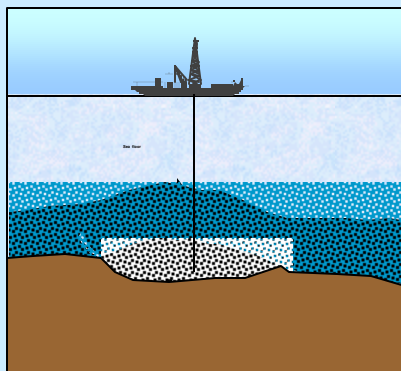


- What is the shear strength?
- What is the change in strength when the hydrate melts?
- What is the porosity and permeability of the sediment?
- What does fluids flow at different rates do to the sediment?
- How much of the sediment will be produced with the hydrate gas?

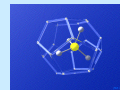


## Hydrate Production And Safety

Hydrate drilling safety is well known but remains a topic of ongoing investigation.

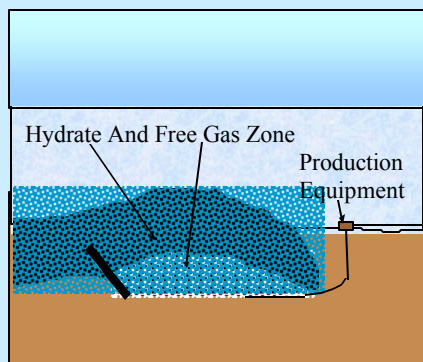


- Plugging of well choke and kill lines
- Formation inside the BOP ram cavities.
- Annular plug around drill string in riser, BOP or casing.
- Sticking drill pipe as well as affecting circulation.
- Plug between drill pipe and BOP preventing closure of BOP and hindering drill string movement.
- External hydrates can cause wellhead connectors to become inoperable with subsidence around the wellbore.

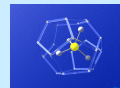


## Hydrate Production And Safety

Several methods have been proposed to produce and enhance the flow rate of hydrate gas.



- Depressurizing the free gas zone.
- Very long horizontal wells.
- Multilateral wellbores.
- Circulating heated water from the surface or a deeper formation.
- Circulating oil from deeper formations.
- Carbon dioxide replacement
- Microwave or acoustic energy input.
- Mining



## Hydrate Production And Safety

### SUMMARY

- Hydrates are a huge untapped U.S. energy resource.
- Several technical areas require development before hydrates can be produced economically.
- Social pressures and technology advancements could have a significant impact on natural gas demand leading to a requirement to develop hydrates in the near future.